

THE ABSORPTION-SPECTRUM OF OXYGEN AND A NEW LAW OF SPECTRA.

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The remarkable multiplex bands known as the A, B, and α lines of the solar spectrum are known to be due to absorption of the sun's light by the oxygen of the earth's atmosphere, and in spite of their obviously rhythmic structure, have not yet been reduced to an algebraical formula as regards their wave-lengths. This the author has succeeded in doing, but the formulæ are of a new type, quite different from those of Balmer, Kayser and Runge, and Rydberg (which are functions of n^{-2} , whereas the author's formulæ depend on n^{+2} , in both cases n standing for the successive whole numbers). From the following tables it will be seen that the agreement between calculation and observation is excellent.

"Head" of A line.—This consists of a tangled pair-system starting from two slightly different fundamentals of oscillation-frequency (*in vacuo*) 13164·7 and 13163·9; the subsidiary lines differ by $0\cdot175n^2$ and $0\cdot184n^2$ respectively.

Value. of n	First Members of Pairs.			Value of n .	Second Members of Pairs.		
	Frequency Calculated from $13164\cdot7 - 0\cdot175n^2$.	Frequency Observed (<i>in vacuo</i>).	Error.		Frequency Calculated from $13163\cdot9 - 0\cdot184n^2$.	Frequency Observed (<i>in vacuo</i>).	Error.
0	13164·7	13164·6	0	1	13163·7	13163·6	+ 0·1
1	13164·5	(double)		2	13163·2	(double)	- 0·3?
2	13164·0	13163·5?	+ 0·5?	3	13162·3	13162·4	- 0·1
3	13163·1	13162·5?	+ 0·6?	4	13161·0	13161·2	- 0·2
4	13161·9	13161·4?	+ 0·5?	5	13159·3	13159·5	- 0·2
5	13160·3	13160·0	+ 0·3?	6	13157·3	13157·4	- 0·1
6	13158·4	13158·2	+ 0·2	7	13154·9	13155·0	- 0·1
7	13156·1	13156·0?	0?	8	13152·1	13152·2	- 0·1
8	13153·5	13153·5	0	9	13149·0	13149·0	0
9	13150·5	13150·6	- 0·1	10	13145·5	13145·5	0
10	13147·2	13147·3	- 0·1	11	13141·6	13141·6	0
11	13143·5	13143·7	- 0·2	12	13137·4	13137·3	+ 0·1?
12	13139·5	13139·7	- 0·2	13	13132·8	13132·7	+ 0·1
13	13135·1	13135·3	- 0·2	14	13127·8	13127·7	+ 0·1
14	13130·4	13130·6	- 0·2				
15	13125·4	13125·5	- 0·1				

The observations of the closer pairs near the fundamental are somewhat defective. After the 15th pair there comes a break, and then the "tail" of A commences, again consisting of pairs. The author has suc-

ceeded in explaining this "tail" in terms of two fundamentals lying close to those of the head.

"Tail" of A line.—

Value of n .	First Members of Pairs.		Value of n .	Second Members of Pairs.	
	Frequency Calculated from $13167.1 - 0.1845(n+16)^2$.	Error.		Frequency Calculated from $13164.6 - 0.1833(n+15)^2$.	Error.
1	13113.8	+ 0.1	1	13117.7	+ 0.1
2	13107.3	- 0.1	2	13111.6	+ 0.1
3	13100.5	- 0.3 ?	3	13105.2	+ 0.1
4	13093.3	- 0.2 ?	4	13098.4	+ 0.1
5	13085.75	- 0.25 ?	5	13091.3	+ 0.1
6	13077.8	- 0.2 ?	6	13083.7	0
7	13069.5	- 0.2 ?	7	13075.9	0
8	13060.8	- 0.1 ?	8	13067.6	0
9	13051.8	- 0.1	9	13059.0	0
10	13042.4	0	10	13050.0	0
11	13032.6	0	11	13040.7	0
12	13022.5	0	12	13031.0	+ 0.1
13	13011.95	0	13	13020.9	+ 0.1
14	13001.05	0	14	13010.4	- 0.1 ?
15	12989.8	+ 0.1 ?	15	12999.6	- 0.1 ?
16	12978.2	+ 0.1 ?	16	12988.4	- 0.1 ?
17	12966.4	+ 0.1 ?	17	12976.8	- 0.1 ?

By these formulæ the whole of the observed lines in the A complex are accounted for, except one isolated line at 13124.6, which is possibly not a true oxygen line.

The B complex is a very close imitation of A, and consequently the formulæ required only differ as regards the constants.

Head of B.—The more accurate formulæ are—

$$\left\{ \begin{array}{l} 14555.5 \\ 14557.7 \end{array} \right\} - 0.26n^2 + 0.11n,$$

which give all the lines with a maximum error of ± 0.15 ; but the simpler formula given in the following table is almost as accurate, and is strictly analogous to that of the A line:—

Value of n .	Frequency Calculated from $14555.7 - \frac{1}{4}n^2$.	Error Compared with Observed Values.	Value of n .	Frequency Calculated from $14557.7 - \frac{1}{4}n^2$.	Error Compared with Observed Values.
1	14555.5	0	1	14557.5	0
2	14554.7	0	2	14556.7	- 0.1
3	14553.5	0	3	14555.5	0
4	14551.7	0	4	14553.7	- 0.3 ?
5	14549.5	- 0.1	5	14551.5	- 0.2
6	14546.7	- 0.2	6	14548.7	- 0.2
7	14543.5	- 0.1	7	14545.5	- 0.1
8	14539.7	- 0.1	8	14541.7	- 0.1
9	14535.5	0	9	14537.5	+ 0.1
10	14530.7	+ 0.1	10	14532.7	+ 0.2

In the same way the tail of B is given by the formulæ—

$$14559\cdot6 \pm 1 - \frac{1}{4}(n + 12)^2.$$

“Tail” of B.—

Value of n .	Frequency Calculated from $14560\cdot6 - \left(\frac{n+12}{2}\right)^2$.	Error.	Value of n .	Frequency Calculated from $14558\cdot6 - \left(\frac{n+12}{2}\right)^2$.	Error.
			0	14522·6	+ 0·2
1	14518·4	+ 0·1	1	14516·4	+ 0·2
2	14511·6	0	2	14509·6	0
3	14504·4	0	3	14502·4	0
4	14496·6	0	4	14494·6	– 0·1
5	14488·4	0	5	14486·4	– 0·1
6	14479·6	– 0·1	6	14477·6	– 0·2
7	14470·4	0	7	14468·4	– 0·2
8	14460·6	– 0·1	8	14458·6	– 0·2
9	14450·4	0	9	14448·4	– 0·1
10	14439·6	+ 0·1	10	14437·6	– 0·1
11	14428·4	+ 0·2	11	14426·4	0
12	14416·6	+ 0·2	12	14414·6	0

In the B series there is again one observed line unaccounted for, viz., that at 14556·1; it has probably been wrongly observed.

The α complex has been too little observed to work its formula out, but it is of the same type, with a head commencing at 15923·6 (double), and a pair series beginning at 15915·8 and continuing (after a break) at 15894·9.

The author has also found a connexion between the constants of A and B: the ratio ($= \phi$) of the fundamental oscillation-frequencies is 1·10586 for both pairs; and the cube of this is the ratio of the coefficients of n^2 , viz., $0\cdot25 \div 0\cdot175$.

This investigation shows that the vibrations of O_2 are due to one system only, and that that system is very slightly unsymmetrical (to account for the pairs). Probably one oxygen atom has a few more electrons attached to it than the other has.